



Monitoring Northern Spotted Owls on Federal Lands in Marin County, California

2008 Annual Report

Natural Resource Technical Report NPS/SFAN/NRTR—2010/312



ON THE COVER

Northern spotted owl (*Strix occidentalis caurina*) platform nest in Douglas-fir (*Pseudotsuga menziesii*), with the female and one nestling visible. Photograph by: Heather Jensen

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Heather J. Jensen ¹

William W. Merkle ²

David Press ¹

¹ National Park Service
San Francisco Bay Area I&M Network
Point Reyes National Seashore
1 Bear Valley Road
Point Reyes Station, California 94956

² National Park Service
Golden Gate National Recreation Area
Bldg 201, Fort Mason
San Francisco, CA 94123

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Abstract

This report provides a summary of results from the 2008 field season of the National Park Service's (NPS) northern spotted owl (*Strix occidentalis caurina*) monitoring program in Marin County, California. The northern spotted owl has been listed as a federally threatened species since 1990. The Marin County population of spotted owls is of interest because of its isolation from other populations, high density and fecundity, and because only recently has this population been affected by the expansion of barred owls (*S. varia*).

The goals of our northern spotted owl monitoring program are to estimate trends in spotted owl occupancy and fecundity within the NPS legislative boundary in Marin County.

A total of 25 known spotted owl territories ("sites") were randomly selected and monitored using standardized methods during the 2008 breeding season. An additional six sites were monitored based on resource management needs of the land management agencies involved in the project. Spotted owl fecundity in 2008 was the highest reported, while pair occupancy was at its lowest level over the program's 10 years of monitoring. Five of the 25 historic spotted owl territories were unoccupied in 2008. Pairs of spotted owls occupied 60% or 15 of the 25 long-term monitoring sites. Of the 13 females with known reproductive status, 10 females (77%) attempted nesting. All 10 females successfully nested, yielding a confirmed total of 18 young. A total of three non-nesting females were confirmed at the 25 sites. In 2008, the fecundity estimate of 0.69 (SE ± 0.12) was well above the average fecundity of 0.39 (SD ± 0.23) measured at monitoring sites from 1999 to 2008.

The decline in spotted owl occupancy may be explained by an expanding presence of barred owls, a competing species, within the study area. In 2008, spotted owls were secretive and difficult to detect at several territories and four spotted owl nests went undetected until fledglings were observed. This imperfect detection of spotted owls may indicate the suppression of spotted owl vocalizations or displacement of spotted owls from their territories as a result of barred owl residency.

At least three adult barred owls are known to have established territories on federal lands in Marin County (a pair and a single male). In 2008, barred owls responded to calling surveys from four historic spotted owl territories, all where barred owls have been detected in years prior. Barred owls were detected on a total of eight spotted owl surveys. Only one of the eight surveys also detected a spotted owl. Four of the five spotted owl sites determined to be unoccupied were within three kilometers of a resident male barred owl. For the second consecutive year, we found evidence of barred owl reproduction at Muir Woods producing at least two fledglings.

We recommend continued annual monitoring of the spotted owl population, and continuing to share information and work with land managers and county officials to reduce potential adverse impacts of projects on spotted owls. Research focused specifically on barred owls and their impacts on spotted owls should be initiated. In addition, studies investigating the effects of Sudden Oak Death on spotted owls also are needed. NPS should continue to provide outreach materials related to spotted owl awareness and recovery.

Acknowledgments

This project has been made possible by funding from the following agencies and organizations: San Francisco Bay Area Network Inventory and Monitoring Program, Point Reyes National Seashore, Golden Gate National Recreation Area, Muir Woods National Monument, Golden Gate National Parks Conservancy, and Point Reyes National Seashore Association. The NPS monitors spotted owls in cooperation with PRBO Conservation Science, Marin Municipal Water District, Marin County Open Space District, and California State Parks.

This project is possible through the assistance of numerous staff members from past years. Daniel George of NPS designed our database and additional field guidance and supervisory contributions have been made by Sarah Allen, Geoff Geupel, Daphne Hatch, Marcus Koenen, and Mia Monroe. Thanks to Rachel Townsend, Dave MacKenzie, and Stephanie Bishop who helped with surveys at Golden Gate National Recreation Area. Last, but not least, thank you to Dan Munton, Matt Divens, and Rick Johnson for their continued assistance with surveys at Point Reyes National Seashore.

Introduction

The mission of the National Park Service (NPS) is “to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations” (NPS 1916). To uphold this goal, the Director of the NPS approved the Natural Resource Challenge to encourage national parks to focus on the preservation of the nation’s natural heritage through science, natural resource inventories, and expanded resource monitoring (NPS 1998). Through the Challenge, 270 parks in the national park system were organized into 32 inventory and monitoring networks.

The San Francisco Bay Area Network (SFAN) includes Eugene O’Neill (EUON), John Muir (JOMU), and Fort Point (FOPO) National Historic Sites, the Presidio of San Francisco (PRES), Muir Woods (MUWO) and Pinnacles National (PINN) Monuments, Point Reyes National Seashore (PORE), and Golden Gate National Recreation (GOGA). The network has identified vital signs, indicators of ecosystem health, which represent a broad suite of ecological phenomena operating across multiple temporal and spatial scales. The intent of SFAN has been to monitor a balanced and integrated “package” of vital signs that meets the needs of current park management, but will also be able to accommodate unanticipated environmental conditions in the future. Northern spotted owls represent a vital sign for SFAN due to their federally threatened status, ecological significance, and high interest to the public (Adams et al. 2006; Adams et al. In Prep).

Life History

The northern spotted owl has been listed as a federally threatened species under the Endangered Species Act since 1990. Northern spotted owls inhabit forested regions from southern British Columbia through Washington, Oregon, and northwestern California. They reach the southern limit of their range in Marin County, California, north of San Francisco, where they occur on NPS lands (Golden Gate National Recreation Area, Muir Woods National Monument, Point Reyes National Seashore), and other public and private lands in Marin County.

In the majority of their range, northern spotted owls are typically found in mature coniferous forests (Forsman et al. 1984). In Marin County, they inhabit second growth and old growth Douglas fir (*Pseudotsuga menziesii*), coast redwood (*Sequoia sempervirens*), bishop pine (*Pinus muricata*), mixed conifer-hardwood, and evergreen hardwood forests. All forest types and ages contain a significant hardwood component. A nest site occurrence model developed in cooperation with PRBO Conservation Science indicated that forest connectivity, areas with more forest cover, less forest edge and urban development, and topographic conditions such as locations lower in the watershed, closer to streams, and more south-facing aspects, were the strongest predictors of spotted owl presence (Stralberg et al. 2009).

Spotted owls in Marin County use a variety of tree species of differing sizes for nesting, and typically nest in platform structures, with relatively few nests in cavities. Platform nesting structures in Marin have included tree forks, large limbs, broken top trees with lateral branches, old raptor, corvid, squirrel, and woodrat nests, debris piles, poison oak tangles (*Toxicodendron diversilobum*) and dwarf mistletoe infestations (*Arceuthobium* spp.). Cavity nests included both

side entry and top entry cavities. Spotted owl nests have been documented in tree species including coast redwood, Douglas-fir, bishop pine, California bay (*Umbellularia californica*), tanoak (*Lithocarpus densiflorus*) and coast live oak (*Quercus agrifolia*).

An inventory of most of the forested habitat in Marin County was conducted in 1997 and 1998 (Chow and Allen 1997; Chow 2001), with a second inventory focusing on federal lands in Marin conducted in 2006 (Jensen et al. 2007). Monitoring of the Marin spotted owl population has occurred from 1999-2008 (Hatch et al. 1999; Fehring et al. 2001; Fehring et al. 2002; Fehring et al. 2003; Fehring et al. 2004; Jensen et al. 2004; Jensen et al. 2006; Jensen et al. 2008). The Marin County study area supports the highest density of northern spotted owls within this subspecies' range (Blakesley et al. 2004). Based on a recent analysis, the density of spotted owl activity sites was estimated to be 0.52 owls/km², which is slightly higher than a previous Marin County estimate due to the discovery of several additional owl sites and the use of a more limited, geographically relevant boundary for the study area (Chow 2001; Stralberg et al. 2009). As part of range-wide demographic analysis, adult survival and fecundity in Marin County were apparently stable from 1998-2003 (Anthony et al. 2006). Out of a total of 14 study sites, fecundity of adult females in Marin was the second highest and the Marin adult survival estimates were similar to most other sites (Anthony et al. 2006).

Spotted owls in Marin County forage primarily on dusky-footed woodrats (*Neotoma fuscipes*), which make up over 75% of their diet by weight (Chow and Allen 1997; Fehring 2003). Zabel et al. (1995) found that in areas where the dusky-footed woodrat is the primary prey species, spotted owls tend to have smaller home ranges and higher reproductive rates. This may explain the high density and fecundity estimates of the spotted owl population in Marin County (Chow 2001; Anthony et al. 2006; Jensen et al. 2007). Other prey species taken by spotted owls in Marin includes small mammals such as deer mice (*Peromyscus maniculatus*), California meadow vole (*Microtus californicus*), and brush rabbit (*Sylvilagus bachmani*) as well as a variety of forest-dwelling birds (Chow and Allen 1997; Fehring 2003).

Threats to the Population

In 2008, the Northern Spotted Owl Recovery Plan identified three high ranking concerns to the conservation of the spotted owl: (1) declining suitable habitat, (2) isolation of populations, and (3) decline in the population (USFWS 2008). The Recovery Plan acknowledged that protecting and managing spotted owl habitat alone is not adequate for spotted owl recovery and the U.S. Fish and Wildlife Service prioritized barred owls as a significant and complex threat (USFWS 2008). The suite of threats present in Marin County mirrors the range-wide concerns and reflects the area's close proximity to the greater San Francisco Bay area. Threats (ranked according to perceived risk level in Marin) include: (1) interspecific competition due to the continued range expansion of the barred owl, (2) loss of habitat resulting from urban development along open space boundaries and increased risk of catastrophic wildfire, (3) structural changes in forest heterogeneity due to Sudden Oak Death, (4) genetic isolation, (5) disturbance due to intense recreational pressures, and (6) West Nile virus.

The threat from barred owls is of particular concern to the spotted owl population in Marin County (Anthony et al. 2006). Barred owls have expanded their range from the eastern United States west across the Canadian Rocky Mountains and down the west coast. Barred owls exploit

the same forested habitats and prey species as spotted owls. However, barred owls are slightly larger than spotted owls and can exhibit aggressive behavior toward spotted owls. Temporary and permanent displacement of spotted owl pairs from their historic sites as a result of the spread of barred owls into the spotted owl's range has been documented by biologists in the Pacific Northwest (Gremel 2000) and the sharpest declines in the spotted owl population have occurred in the northern portion of the spotted owl's range where barred owls have been present the longest (Anthony et al. 2006). Evidence of negative effects of barred owls on spotted owls include territorial exclusion (Hamer 1988; Hamer et al. 2007) and declines in site occupancy (Kelly et al. 2003; Olson et al. 2005), reproduction (Olson et al. 2004), and apparent survival (Anthony et al. 2006). Barred owls were first detected in Marin in 2002, and have been documented as reproducing in 2007 and 2008. Physical confrontations and aggressive interactions between barred and spotted owls have been documented at multiple spotted owl sites within Marin County.

Small populations at the edges of a species' range have a much higher risk of local extinction, due to environmental and demographic stochasticity (Gilpin and Soulé 1986). The Marin population is isolated from the spotted owl populations to the north and shows no evidence of hybridization with California spotted owls (*S. o. occidentalis*; Henke et al. 2003; Barrowclough et al. 2005). A break in forested habitat, expansive grasslands and anthropogenic development serve as dispersal barriers and has isolated the Marin population from its northern counterparts. Barrowclough et al. (2005) indicated that due to the apparent genetic isolation of Marin County's spotted owl population, the population warrants special management attention.

Currently, forests in Marin County are heavily infested by the pathogen Sudden Oak Death (*Phytophthora ramorum*). At several locations within Point Reyes National Seashore, tanoak mortality has exceeded 95% by basal area (Moritz et al. 2008). The die-off of native coast live oak and tanoak species is locally important because it results in shifts in plant species composition, possible reduction in plant species richness, and potential impacts on forest dynamics. Specifically, the spotted owl's dominant prey item in this area, the dusky-footed woodrat (Chow and Allen 1997; Fehring 2003), use tanoaks for cover and forage (Sakai and Noon 1993). Sudden Oak Death may also amplify fuel load accumulations and increase the potential and severity of fires.

NPS lands in Marin County are situated within the immediate San Francisco Bay Area and receive several million human visitors each year. Spotted owl nest sites in Marin County are generally close to roads and trails. This is likely the result of the high density of trails and fire roads located within potential spotted owl habitat and the tendency to locate trails in riparian drainages where owls often nest. As a result, spotted owls in the region have a high potential for interaction with humans. Furthermore, spotted owl territories located on a matrix of public and private lands or near the wildland-urban interface face an increased risk of injury and death due to effects of human related activities including poisoning, domestic animal interactions, nest site disturbance, and collisions with vehicles.

Monitoring Objectives

There are three current monitoring objectives for the SFAN northern spotted owl monitoring program (Adams et al. In Prep).

1. Monitor long-term trends in northern spotted owl site occupancy rates of territories within the legislated NPS boundaries of Marin County, California.
2. Monitor long-term trends in northern spotted owl fecundity (number of female young per territorial female) within northern spotted owl territories within the legislated NPS boundaries of Marin County, California.
3. Determine long-term trends in northern spotted owl nest site characteristics including nest tree metrics and abiotic and biotic habitat characteristics to evaluate changes in nesting habitat association within the legislated NPS boundaries of Marin County, California.

Methods

Study Area

Our study area is within a 13,889-hectare (34,320-acre) forested area of Marin County and includes suitable spotted owl habitat inside or within 400 meters (0.25 mile) of the legislative boundaries of GOGA, MUWO, and PORE (Figure 1; Jensen et al. 2006). California State Park (CSP) lands in Mount Tamalpais State Park and Samuel P. Taylor State Park are included in the study area, but Tomales Bay State Park is outside of the federal boundary; thus, its spotted owl habitat and known territories have been excluded from the study and are not included in the acreage calculation. Also not included in the study area acreage calculation are additional management sites that occurred outside the perimeter of federal lands on CSP, the City of Mill Valley, the Marin Municipal Water District, and the Marin County Open Space District lands.

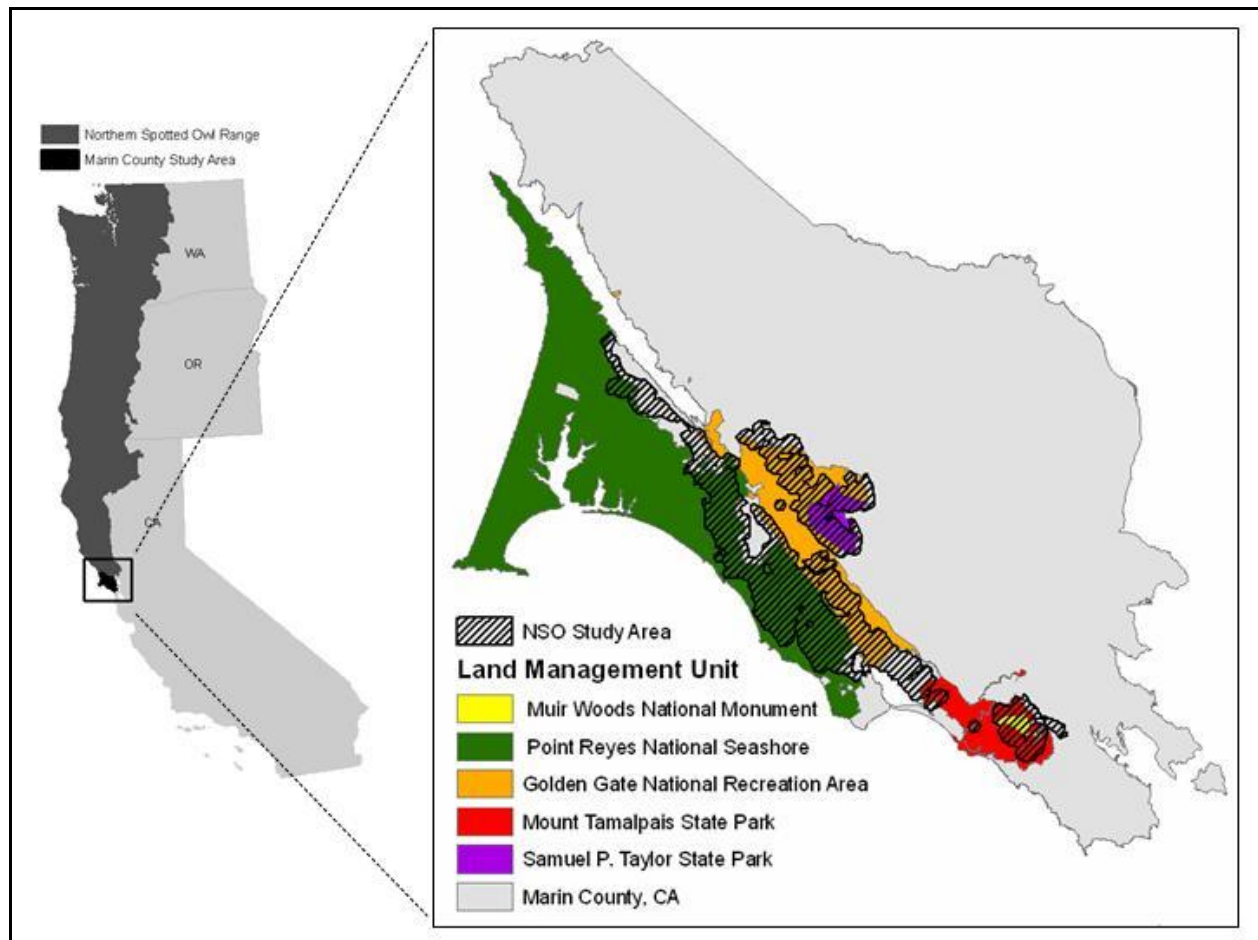


Figure 1. Northern spotted owl range map and Marin County study area. On the left, the dark gray shows the northern spotted owl's range and the black square is centered on Marin County. On the right, land management units included in the Marin County study area are color coded. The study area itself is shaded in black, diagonal lines.

Monitoring History and Study Design

In a 1997-1998 spotted owl inventory study, all evergreen forest habitat located on federal lands within Marin County was thoroughly and systematically surveyed for spotted owl presence using the USFWS protocol (USFWS 1992). Additional surveys on Marin Municipal Water District (MMWD) and Marin County Open Space District (MCOSD) were completed in 1999 (Hatch et al. 1999). A total of 83 spotted owl sites, including 53 pairs, were identified on public lands in Marin County (Chow and Allen 1997; Hatch et al. 1999; Chow 2001).

Between 1999 and 2005, 46 sites were monitored for occupancy and fecundity and nest site characteristics were collected (Hatch et al. 1999; Fehring et al. 2001; Fehring et al. 2002; Fehring et al. 2003; Fehring et al. 2004; Jensen et al. 2004; Jensen et al. 2006). The sites were chosen to represent a variety of habitat types, ongoing management concerns, accessibility, and funding availability. Due to a non-random selection process, we were concerned that the study design limited our ability to make valid inference across federal lands in Marin County. As a result, we are developing a study design that allows us to make inferences to all federal lands in Marin County (see Adams et al. In Prep).

To create a within-subject study design to detect trends toward declines in occupancy and fecundity for all federal lands in Marin County, we first completed a single year inventory study in 2006 to assess the spotted owl population on all suitable habitat (Jensen et al. 2007). This single year inventory effort utilized a model that predicted spotted owl nest-site occurrence based on habitat suitability (Stralberg et al. 2009). We applied a 400 meter buffer around the habitat model's boundary and restricted our study area to include buffered lands within 400 meters of the legislative boundary of MUWO, PORE, and GOGA. We used a hybrid of the Marin Modified Protocol (Fehring et al. 2001) and the U.S. Fish and Wildlife Service's protocol (USFWS 1992) and standardized search procedures (Jensen et al. 2007). As a result, 65 areas, which included 43 known spotted owl territories and 22 other areas with no known established territories, were inventoried for occupancy. At a minimum, a single spotted owl was detected at 59 of the 65 areas, and pairs occupied 43 territories (Jensen et al. 2007).

In 2007, a randomly selected subset of 25 sites was obtained from 47 spotted owl sites that had known pair occupancy in at least one year from 1997-2006 (Jensen et al. 2008). The same 25 sites established in 2007 were monitored in 2008. Each year there are sites that need to be monitored for management purposes, but these sites are not included in fecundity analyses because they are not randomly selected.

Field Methods

Standard spotted owl survey protocols may lead to changes in owl behavior due to repeated calling and the feeding of live mice (*Mus domesticus*) to owls (known as "mousing"). Owls habituated to people may be more vulnerable to disturbance and manipulation by park operations and visitors. In Marin County, a modified protocol has been developed collaboratively between the National Park Service and PRBO Conservation Science that reduces the number of mice used to obtain the relevant nest site and reproductive information (Fehring et al. 2001; Adams et al. In Prep). The ease of access to nest sites and high visibility of nesting structures facilitates intensive nest checks and obviates the need to use mice to monitor reproductive status. Consequently, we

rely on increased search time, more frequent visits and owl behavioral observations to gather the data.

All long-term monitoring surveys (1999-2005 and 2007-2008) for occupancy and reproductive information follow the Marin Modified Protocol developed for use in areas with high potential owl/human interaction (Fehring et al. 2001; Adams et al. In Prep). The “Modified Protocol for Spotted Owl Monitoring and Demographic Studies in Marin County California” (Fehring et al. 2001) is modeled directly from the widely used “Spotted Owl Monitoring Protocols for Demographic Studies” (Forsman 1995). Survey methods include visual surveys of previous activity centers and nest sites, playback calling and hooting both during the day and at night, mousing, visual nest checks, and counts of fledged young. Spotted owls are sexed based on vocalizations and aged by tail feather shape and coloring (Forsman 1983). Barred owl detections are noted, and reports of barred owls in or around the study area are investigated, but there are no specific methods utilized for specifically monitoring barred owls. An annual breeding status is assigned to the individual owl territories monitored and is determined using criteria in the Marin Modified Protocol.

All owl activity centers (either nest location or major roost site) are recorded in Global Positioning System (GPS) coordinates using a Garmin 3+ or similar GPS unit. Roost sites or nest trees for which GPS satellite access is not available are mapped on topographic maps from compass bearings taken in the field and GPS coordinates are obtained by using ArcGIS 9.2 (ESRI 2007). Each year, at every known nest location, nest tree parameters are measured and surrounding habitat is described using a standardized methods found in our monitoring protocol (Adams et al. In Prep).

Data Management and Distribution

All site search, owl detections, and nest record field data are compiled in a Microsoft Access database maintained at PORE. All areas surveyed are mapped using ArcGIS 9.2 GIS software program and the data layers are made available to agencies involved in land management and planning projects within Marin County. The 1999 through 2007 spotted owl location data was submitted to the CA Natural Diversity Database Project (Rarefind) and the Biogeographic Information and Observation System (BIOS) database. In addition, we provide the U.S. Department of Fish and Game and the Marin County Development Agency with spotted owl locations.

Summaries and Reporting

For reporting purposes, in 2008 we established new criteria for inclusion or exclusion of spotted owl sites from annual data summaries. The new criteria were necessary to standardize the reporting process and allow repeatability and robust comparisons among years. In annual reports prior to 2008, data from 1999-2005 was reported for 46 long-term monitoring sites. In 2008, we restricted the inclusion of those 46 sites to only the 36 that fell within our re-designed study area (see above). We also excluded 1997 and 1998 from the summaries due to the difficulty in interpreting the data to determine survey purpose and effort level. Although non-randomly selected, we justified including 12 management sites (number of management sites varied annually) and 14 inventory areas in the analyses if the sites or areas received an adequate level of survey effort for the years 1999-2006.

The 2006 data is excluded from the annual summaries for reproductive success and fecundity since the purpose of the single year inventory was to determine presence/absence. Additional sites monitored in 2007 and 2008 for purposes other than demography (i.e. management sites) were not included in the summaries. Any differences from previously reported results can be attributed to the application of the new criteria to the long-term spotted owl data.

Results

From March 4 to August 4, 2008, the survey teams made 146 visits (mean visits/site = 5.8, range 2-10) to the 25 study sites monitored for the purpose of determining occupancy and fecundity (Table 1). A summary of results are reported in Table 1.

Table 1. Summary of the spotted owl monitoring results for the 2008 breeding season.

Number of sites monitored	Number of occupied territories	Number of sites occupied by pairs	Number of sites with known reproductive outcomes	Number of nests located	Number of young produced	Fecundity
25	20	15	13	6	18	0.69

Age and Sex Determination

We positively sexed and aged a total of 27 (15 males and 12 females) spotted owls in 2008. In other study areas where banding occurs, sexing and aging is easily determined with a re-sighting of the owl's band, but in the Marin study area only a small proportion of the owls are banded. On numerous occasions when a single owl or pair was located, but without band identification, biologists relied on sexing the owl in view based on vocalizations and aging the owl based on tail feather wear (Forsman 1983). Many owls remained silent during daylight survey hours and only vocalized at night making it impossible to assign ages to the corresponding sex, resulting in an overall decrease of age determinations in 2007 and 2008. In 2008, adults constituted 89% or 24 of the 27 spotted owls whose age was identified. Two second-year sub-adults (7%) and one sub-adult in which the age could not be further determined (3%) were located. At 12 spotted owl territories, we were able to age both pair members. Ninety-two percent of the 12 pairs in 2008 were composed of an adult female and male (Figure 2). In comparison, only 70% of all known age pairings from 1999-2008 were an adult pair (Figure 3).

Occupancy Status

The percentage of sites occupied by pairs or single owls remained fairly constant at roughly 90% from 1999-2007; however, in 2008 the total percentage of sites occupied by pairs or singles dropped to approximately 80% (Figure 4). In 2008 we documented the lowest percentage of sites

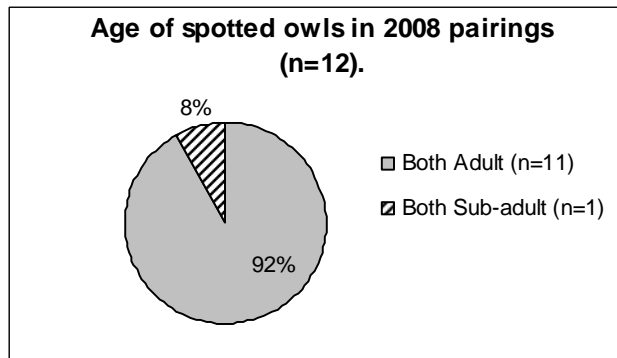


Figure 2. Age of spotted owls in 2008 pairings; n is the number of spotted owl pairs.

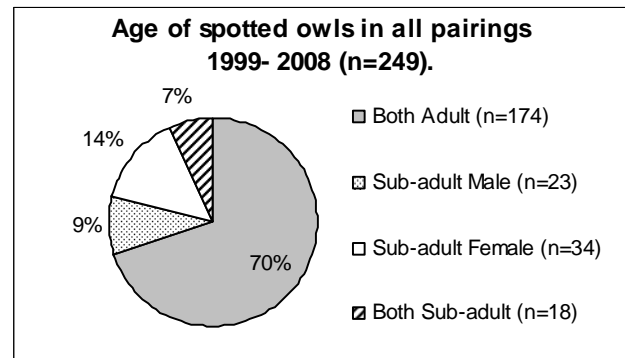


Figure 3. Age of spotted owls in all pairings; n is the number of spotted owl pairs.

occupied by pairs (60%) in a decade of monitoring. Pair occupancy increased from 1999 to 2003 and has declined from 2003 to 2008. Furthermore, the percentage of sites occupied by a single owl (20%) has remained high since 2006 and the percentage of unoccupied sites reached a high of 20% in 2008 on federal lands (Figure 4).

In 2008, the percentage of monitored spotted owl sites with barred owl detections (16%) closely reflected the percentage of unoccupied spotted owl sites (20%; Figure 5). In fact, all four spotted owl monitoring sites within the barred owl's (resident male) Olema Valley territory were determined to be unoccupied during the 2008 breeding season (Figure 6).

On the morning of July 2, 2008, a dead subadult spotted owl was collected on Highway 1 after it had been hit by a vehicle during the night. The collection location on Highway 1 was in the immediate area of the Olema Valley barred owl and within two adjacent spotted owl territories. The dead subadult was the first and only detection of a spotted owl at the two adjacent spotted

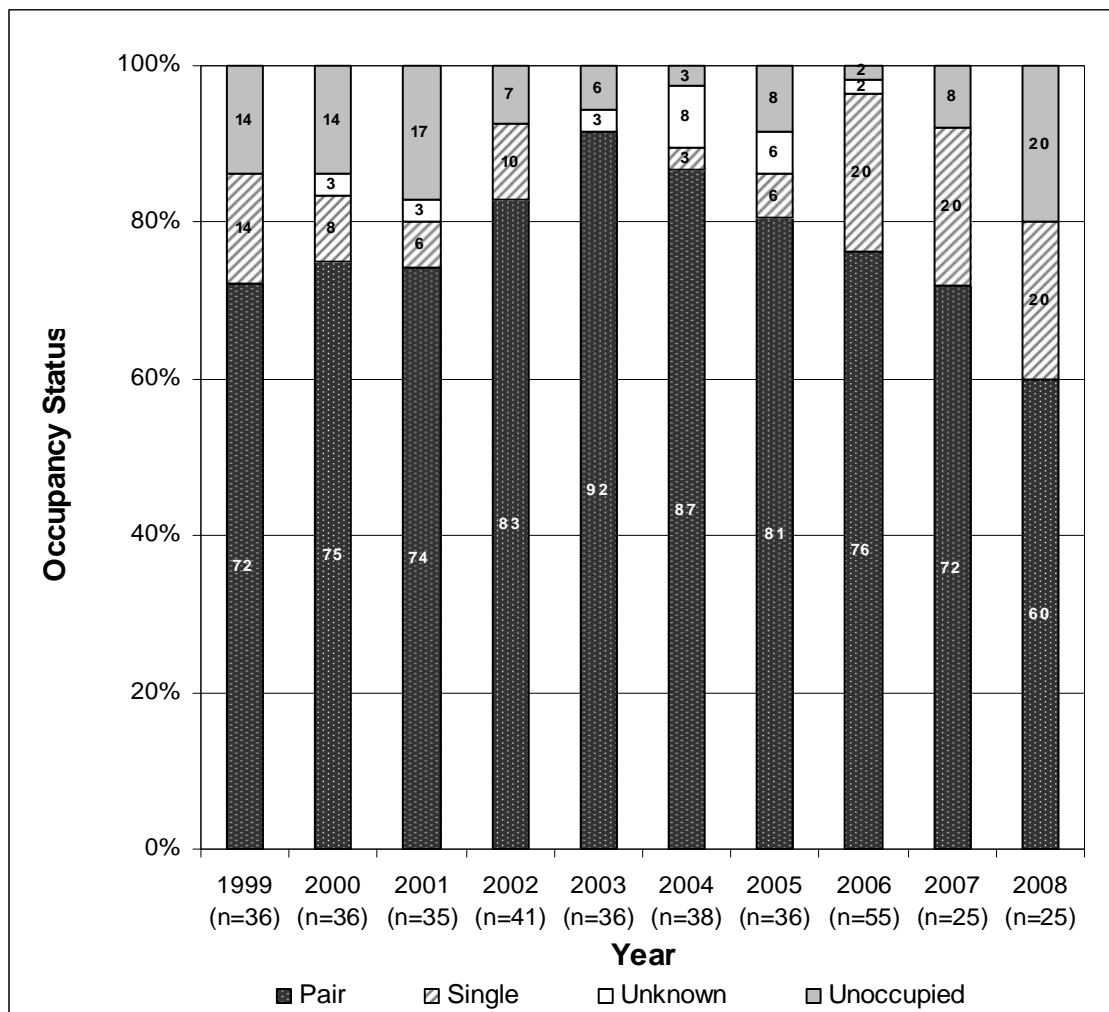


Figure 4. Occupancy status for all study sites (1999-2008). Numbers within the bars are the exact percentage for each status category and n is the total number of spotted owl territories.

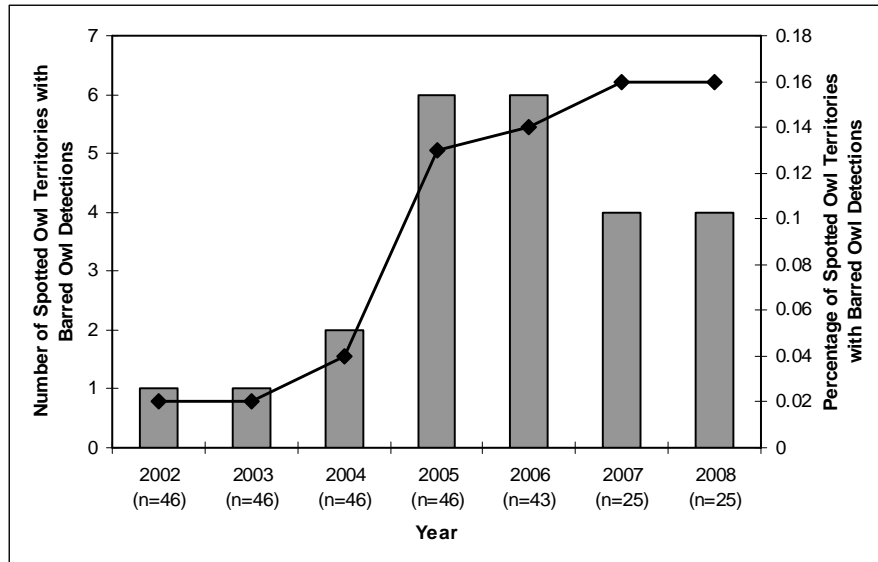


Figure 5. Number and percentage of spotted owl territories with barred owl detections (1999- 2008). The gray bars are the “number of spotted owl territories with barred owl detections” and the diamonds on the black line are the “percentage of spotted owl territories with barred owl detections.”

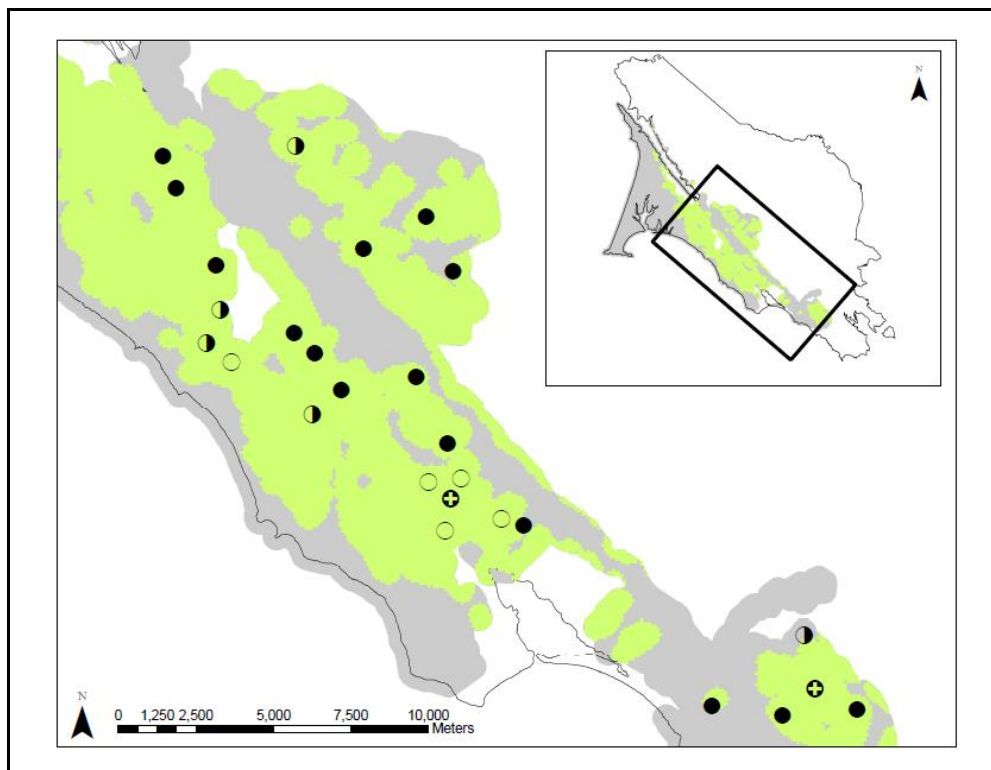


Figure 6. Location and occupancy status of the 25 spotted owl territories in reference to barred owl locations and suitable habitat in the Marin County study area, 2009. Black dots are spotted owl pairs, half-filled circles are single spotted owls, empty circles are unoccupied spotted owl territories, and black circles with a hollow “+” are barred owl locations. Light gray is the study area and light green color is suitable habitat (Stralberg et al. 2009) within the study area boundary.

owl sites where the resident barred owl was heard and seen consistently during the 2008 spotted owl surveys.

Reproductive Status and Fecundity

In 2008, a total of 15 sites were occupied by a pair of spotted owls. Of the 13 females with known reproductive outcomes, 10 females (77%) attempted nesting (Figure 7). All 10 females successfully nested yielding a total of 18 young. Three non-nesting females were confirmed at the 13 sites with known reproductive status and no failed nesting attempts. Fecundity, a measure of productivity, is calculated as the average number of female young produced per territorial female, assuming a 50:50 sex ratio of fledglings. The mean fecundity for the 2008 breeding season was the highest measured in the study's history at 0.69 (SE ± 0.12), well above the average fecundity from 1999-2008 (0.39; SE ± 0.08 ; Figure 8). The above average fecundity in 2008 follows a complete non-breeding year in 2007.

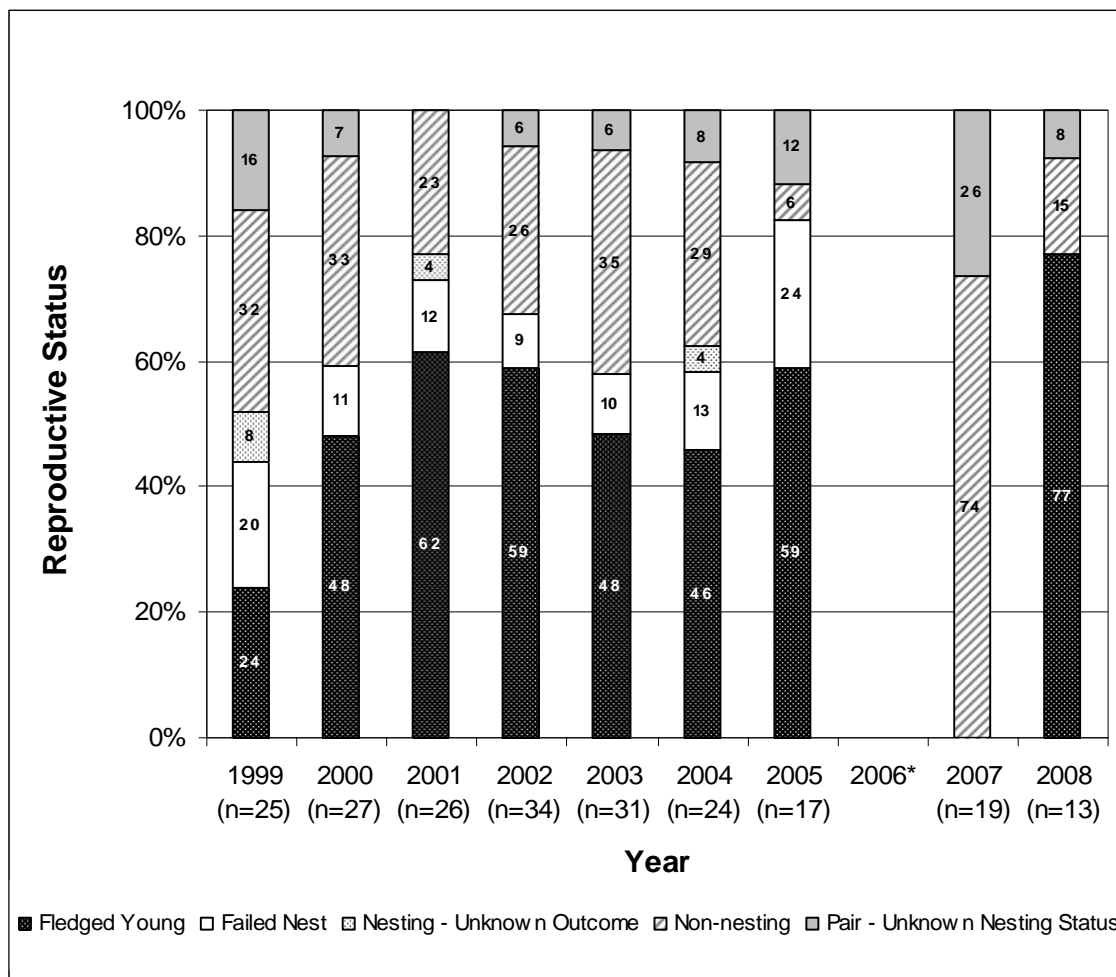


Figure 7. Reproductive status for owl pairs monitored in the NPS study area (1999-2005 and 2007-2008). Numbers within the bars are the exact percentage for each status category and n is the total number of spotted owl territories. *2006 inventory data was excluded from this analysis.

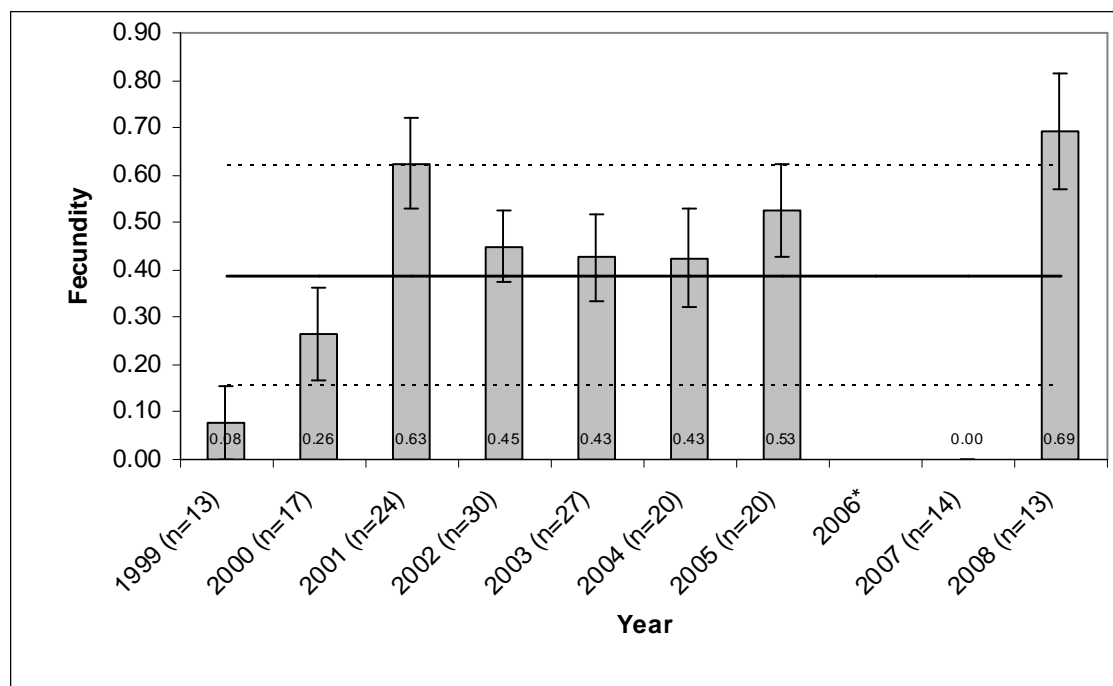


Figure 8. Fecundity for 1999-2005 and 2007-2008. The solid line on the graph is mean fecundity from 1999-2008 (0.39), and the dashed lines are one standard deviation from the mean (0.23). Year error bars indicate ± 1 standard error and n is the total number of spotted owl territories. *2006 inventory data was excluded from this analysis.

Nest Measurements

During surveys from 1999 to 2008, spotted owl researchers have located a total of 101 spotted owl nests (Table 2). Of the 101 unique nests, nine (9%) were in cavities and 92 (91%) were platform nests. This ratio is the opposite of owl nests in older forests where 80-90% of the nests are in cavities, but closely resembles the ratio in other parts of the range where forests are younger (Buchanan and Irwin 1993; Forsman and Giese 1997; LaHaye and Gutierrez 1999). A total of six platform nests were located in 2008.

Over half (51%) of the documented nests have been in Douglas-fir (n=52). The remainder of nest tree species selected include coast redwood (n=34), California bay (n=8), coast live oak (n=6), and tanoak (n=1). The broad range of species and size of trees selected as nest trees indicate a

Table 2. Average nest measurements for 101 unique nests located within the NPS study area from 1999 to 2008.

	Platform Nests (n=92)		Cavity Nests (n=9)	
	Mean	SE	Mean	SE
dbh (cm)	101.0	± 5.55	178.0	± 44.10
Nest height (m)	19.2	± 0.80	21.4	± 4.30
Tree height (m)	34.7	± 1.32	39.9	± 6.91

broader use of forest types and ages in the Marin study area relative to the northern regions of the spotted owl's range. Although the sample size for cavity nests is small, it appears that cavity nests tend to occur in larger trees (Table 2).

Identifications of Banded Owls

Between 1998 and 2003, 110 spotted owls were captured and color banded at 26 sites within a 9,996-hectare (24,700-acre) area surrounding Bear Valley in PORE. In 2004, the banding aspect of the project was ceased due to logistical constraints and limited sample size. We have continued to identify the presence or absence of color bands on all spotted owls encountered.

Of the 110 spotted owls banded, 50 were banded as juveniles, 23 as subadults, and 37 as adults (Fehring et al. 2004). In 2007, 10 banded spotted owls were resighted (2 females and 8 males). Of the seven band resights in 2008, two were adult females and five were adult males. The oldest banded owl observed in 2008 was an 11 year old male which was banded as a second year subadult in 1999. Two band recoveries from deceased spotted owls were reported to PRBO Conservation Science in 2008. One band recovery was a female found in her historic territory and the second spotted owl was originally banded on federal lands, but was recovered on county lands. No cause of mortality was evident in either case.

Barred Owls

The first barred owl record for Marin County occurred in May 2002 in MUWO, and the first known successful reproduction of barred owls occurred in 2007 also at MUWO. In 2008, biologists documented the first known barred owl nest tree in Marin County and confirmed the successful fledging of two barred owls.

Eight separate detections of barred owls were recorded during spotted owl surveys in 2008. Of the eight surveys in which a barred owl was detected, only one also had a spotted owl detection. Six of the eight barred owl detections occurred at three spotted owl sites in the Olema Valley. The remaining two detections were concentrated in the Redwood Creek drainage of MUWO.

Barred owls have been observed hunting signal crayfish (*Pacifastacus leniusculus*) in the Redwood Creek drainage on numerous occasions over multiple years by park visitors and NPS staff. On May 7, 2008, biologists watched a male barred owl hunt on the ground for 25 minutes and successfully capture a broad-footed mole (*Scapanus latimanus*). Pellet samples collected at the 2008 barred owl nest site indicate a diet composed of crayfish and small mammals. Relative to spotted owls, barred owl diet plasticity likely provides a competitive advantage over spotted owls (Livezey et al. 2008). An example of this likely competitive advantage was documented on federal lands in Marin County during the 2007 breeding season. There were no spotted owl nesting attempts, nests, or young located on federal lands in 2007; however the only known barred owl pair successfully nested and produced a maximum count of two fledglings. In contrast to spotted owls, the generalist diet and foraging strategies of barred owls may buffer the species from major fluctuations in reproductive success among years.

Since barred owls in Marin County are not marked, the exact number of individuals cannot be confirmed. Based on the sex determination, frequency and repetition of the incidental barred owl detections, and distance between barred owl detections, at least two males and a female are

current residents of federal lands in Marin County. However, based on incidental detections it is highly likely that there are an additional two or more unknown sex barred owls in Marin County. In 2008, four additional barred owl detections were documented outside of the breeding season and/or beyond the federal legislated boundary.

2008 marked the seventh year a male barred owl has been detected at MUWO, the fifth year a male barred owl was located on the west side of the Bolinas Ridge, and the second year a female has been observed at MUWO. This is the second consecutive year successful breeding of barred owls has been documented in Marin County. To date, no spotted/barred owl hybrids have been detected at any of the long term monitoring sites.

Discussion

Northern spotted owl fecundity in 2008 was the highest reported, while pair occupancy was at its lowest level over the program's 10 years of monitoring. Five of the 25 historic spotted owl territories were unoccupied in 2008.

The cause of the recent decline in pair occupancy and increase in unoccupied territories and territories occupied by a single owl remains unknown, but may be associated with the recent colonization of barred owls into this area in 2002. Declines in spotted owl site occupancy have been seen in other areas where barred owls are present (Kelly et al. 2003; Olson et al. 2005) and are the most severe in areas where barred owl have been established the longest (Anthony et al. 2006). In reviewing barred owl and spotted owl locations in Oregon between 1974 and 1998, Kelly et al. (2003) found that when barred owls invade spotted owl territories, mean annual occupancy of spotted owls decline when compared to territories without barred owls.

In 2008, barred owls responded to calling surveys from four historic spotted owl territories, all where barred owls have been detected in years prior. A spotted owl was only detected at one of the sites, and during only one survey. At several territories in 2008, spotted owls were secretive and difficult to detect, and four spotted owl nests went undetected until fledglings were observed. This imperfect detection of spotted owls may indicate the suppression of spotted owl vocalizations or displacement of spotted owls from their territories as a result of barred owl residency. It is likely we will continue to see declines in spotted owl occupancy rates as barred owls continue expanding their range and become more established in our study area.

The 2008 fecundity estimate of 0.69 (SE ± 0.12) was well above the average fecundity of 0.39 (SD ± 0.23) measured at monitoring sites from 1999 to 2008. The high incidence of experienced pairs at the spotted owl sites monitored may have been one factor contributing to the above average fecundity documented in 2008. Of the 12 spotted owls pairs that we monitored, 11 (92%) were adult pairings. In comparison, only 70% of all known age pairings from 1999-2008 were an adult pair. Anthony et al. (2006) found that the age of females was the primary factor that affected fecundity. Productivity of females increased with age and adults (≥ 3 years old), a factor that contributes the most to population size (Courtney et al. 2004).

Research Activities and Recommendations

Barred Owl Study

There is a great need to study barred owl and spotted owl interactions, to determine the nature of the threat, and identify potential management options to ensure the persistence of spotted owls throughout their historic range (USFWS 2008). The NPS and other agencies are implementing studies across the northern spotted owl's range to gain a better understanding of the interspecific behavior and to learn more about management options to benefit spotted owls in the presence of barred owls. Since the barred owl has only recently invaded the southern extent of the northern spotted owl's range, Marin County offers a unique opportunity to study the early patterns of contact between barred and spotted owls. In Marin County, researchers will continue to track barred owl observations and make efforts to color band barred owls to facilitate tracking individual owls. Staff members and volunteers will continue to be made aware of the potential of

hybridization and the importance of confirming the identity of both pair members. In future years, we will continue to investigate the possibility of implementing a barred owl telemetry study to track barred owl movements, predict areas likely to see barred and spotted owl interactions, and to provide insight to the overlap of diet, habitat use, and interspecific behavior.

Pellet Study

The diet of owls can be identified from the analysis of pellets (casted prey remains). Numerous studies conducted throughout the range of the northern spotted owl have reported the frequency of prey items and the relative biomass of prey items (Forsman et al. 1984). Other studies have provided evidence that prey can have an influence on reproductive success (Zabel et al. 1995; Rosenberg et al. 2003) and home range size (Zabel et al. 1995).

In 2009, the SFAN spotted owl monitoring program will be providing Dr. James Cunningham at Dominican University with spotted owl pellets collected during the 2008 and 2009 breeding seasons for a prey analysis study. Dr. Cunningham has identified undergraduates who will dissect the pellets and identify the prey remains. Each student will develop a research idea in conjunction with Dr. Cunningham and the National Park Service.

Vocalization Study

During the 2006, 2007, and 2008 breeding seasons, spotted owl staff members worked with independent researcher, Rick Johnson, to investigate the potential of identifying individual northern spotted owls through vocalization analysis. Vocal identification has been proven to be an effective tool to distinguish between individuals in the genus *Strix*, specifically the African wood owl (*Strix woodfordii*; Delport et al. 2002). The purpose of the research project was to determine if recordings of owl vocalizations, specifically four note location calls, can be used to identify individual birds. The use of vocalizations as an alternative to banding for individual identification has been proposed for the Mexican spotted owl (*S. o. lucida*; Kuntz and Stacy 1997).

During spotted owl breeding surveys, unsolicited and solicited male and female spotted owl vocalizations as well as incidental barred owl vocalizations were recorded during day and night surveys. The sounds are studied using spectrograms (Figure 9) and five parameters were selected to evaluate the spectrograms. The timing of the calls, pitch of the fourth note, and shape of the fourth note were used to distinguish individual owls. These quantitative measures are based on previous work on northern spotted owls and California spotted owls (Van Gelder 2003).

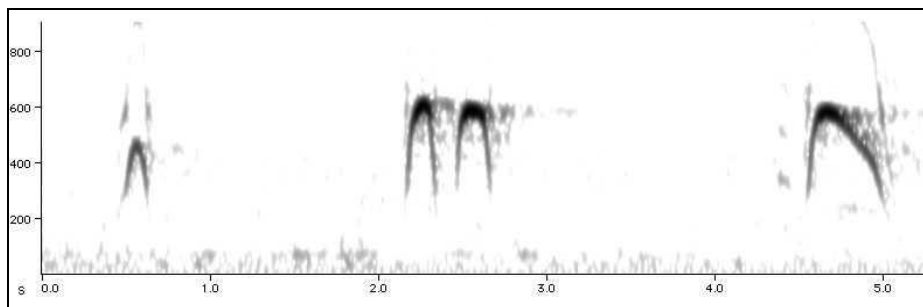


Figure 9. Spectrogram of a spotted owl four-note location call.

Preliminary results indicate that identification of individual spotted owls by vocalization alone is not likely to be an efficient monitoring tool for project staff to utilize in a demographic study. This technique may prove to be appropriate for the identification of a smaller population of barred owl individuals.

Sudden Oak Death

Marin County is one of 14 counties in California affected by the pathogen that causes Sudden Oak Death (SOD). *P. ramorum* is a water mold that acts like a fungus, attacking the trunk of a tree and causing a canker, or wound that eventually cuts off the tree's flow of nutrients. Other secondary decay organisms such as beetles and fungi often move in after the tree is infected. Trees infected with SOD may survive for one to several years as the infection progresses. As the tree finally dies, the leaves may turn from green to brown within a few weeks, hence the appearance of sudden death (Davidson et al. 2003). Tanoaks and coast live oaks are killed by the disease; other species affected are known as "foliar hosts" because their leaves and twigs may be infected. These foliar hosts can spread the disease, but are only occasionally killed.

The diversity of host species affected by *P. ramorum* indicates potential long-term landscape modifications through changes in the forest canopy, understory, and ground layer (Rizzo and Garbelotto 2003). Moritz et al. (2008) found that nearly every stand of tanoak within PORE is already impacted by SOD and at several locations tanoak mortality was greater than 95% by basal area. Tanoak is currently the most common subcanopy species in coniferous forests within the study area and Moritz et al. (2008) suggest that tanoak will be replaced by redwood in redwood forest and California bay in Douglas-fire forests. Changes in forest physiognomy and shifts in forest species composition due to *P. ramorum* have the potential to affect forest ecosystem dynamics including spotted owls and their prey species. For comprehensive information regarding SOD and links to current maps visit the California Oak Mortality Task Force website at www.suddenoakdeath.org.

Management of the pathogen at the spotted owl project level includes incorporating measures to prevent the spread of *P. ramorum*. As the range of SOD expands, simple precautionary measures and decontamination procedures have been added to the monitoring efforts so that owl biologists do not facilitate the transfer of infected plant material or soil to unaffected areas.

West Nile Virus

West Nile virus (WNV) is an arbovirus that first appeared in the Western Hemisphere in New York, in the early fall of 1999. Mosquitoes and migratory birds are the main species involved in the spread of WNV. Mosquitoes are the principle vector and avian species are considered the principle host species for WNV. WNV first appeared in California in 2002. By 2004, WNV had spread to all 58 counties of California and a total of 3,232 birds tested positive for WNV. Statewide, the incidence of WNV has continued to decrease annually. On a local level, since reaching a peak in 2004 of 18 birds testing positive for WNV in Marin County, numbers have continued to steadily decline. As of December 2008, a single house finch (*Carpodacus mexicanus*) tested positive for WNV in Marin County. The top three bird species infected by WNV in California are the American crow (*Corvus brachyrhynchos*), western scrub-jay (*Aphelocoma californica*), and yellow-billed magpies (*Pica nuttalli*). For historical and current information that is updated weekly visit <http://westnile.ca.gov/>.

Raptors and owls have been noted to be particularly susceptible to WNV. A northern spotted owl was confirmed to have died from WNV at a captive wildlife facility, indicating that spotted owls are susceptible to WNV. WNV has been detected within other owl species in California. Future efforts will be made to document fatalities potentially resulting from West Nile Virus. Carcasses should be tested whenever possible and the population should continue to be monitored for declines due to this new threat.

On the evening of July 1, 2008, a local resident reported seeing a spotted owl on the side of Highway 1 that appeared to have been struck by a vehicle. The next morning, an unknown sex subadult spotted owl was found dead on the shoulder of the road in the location described by the local resident. The spotted owl body was collected and sent to U.S. Geological Survey's National Wildlife Health Center in Madison, Wisconsin where it tested negative for WNV and avian influenza.

Management Activities and Recommendations

Humans and their activities, including development along the wildland/urban interface, land management practices, and recreation are among the significant sources of impact in Marin County. In addition, the continued range expansion of the barred owl poses a competitive threat to spotted owls throughout their range (USFWS 2008). We recommend that owl occupancy and reproductive monitoring surveys continue, and that land managers use these data to ensure that management activities do not impact the habitat or the productivity of northern spotted owls. We encourage continued communication between land managers and their maintenance crews in planning and executing projects in spotted owl habitat. Information on owl site locations should continue to be made available to USFWS, all land managers and local city and county planning departments. The central repository for owl detection information in California is the California Department of Fish and Game (CDFG) Natural Diversity Database (www.dfg.ca.gov/whdab/html/cnddb.html) and the Biogeographic Information and Observation System (BIOS) database, also managed by the CDFG.

Given the mixed ownership patterns in Marin County, several owl home ranges contain both public and private lands. Coordination between park managers and local planners is essential. Loss of owl habitat and owl pairs due to residential land management practices (e.g., rodenticide use) and urban development is an urgent local threat. Due to the fragmented and isolated nature of the Marin County forested habitat, declines along the urban edges may impact overall population health throughout the local range.

Public Outreach

Due to the consistent public interaction with Marin County's northern spotted owl population, the NPS has developed educational resources to inform the public of their role of living and working in areas with spotted owls. In 2008, spotted owl biologists worked with interpretative staff to update information on the MUWO website. The goal of the website is to introduce Marin County residents, land owners, and agency managers to basic spotted owl biology, guidelines for protecting spotted owls and owl habitat in this county, and how to minimize potential threats to spotted owls. In 2008, additional outreach included: 1) development and presentation of a scientific poster at The Wildlife Society's Western Section Annual Conference and Spotted Owl

Symposium in February 2008 and for the NPS Natural Resource Programs Manager's workshop in April 2008 and 2) spotted owl informational presentations were presented at the PORE seasonal/new staff training and Marin Audubon Society. Additional materials including executive briefings and past annual reports are made available to the public at the San Francisco Bay Area Network's Inventory and Monitoring website:

http://science.nature.nps.gov/im/units/sfan/vital_signs/Spotted_Owl/birds.cfm

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Natural Resource Program Center
1201 Oakridge Drive, Suite 150
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